FORM PTO-1390 (REV 10-96) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER:

U.S. APPLICATION NO (If known, see 37 CFR 1.5): 09/011160

INTERNATIONAL APPLICATION NO	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/GB96/01773	JULY 24 1996	JULY 26 1995

TITLE OF INVENTION: A MAGNETIC FILTER DEVICE

APPLICANT(S) FOR DO/EO/US: HALL, Harold

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☑ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371
3. ☐ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1)
4. ☐ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☑ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   - a. ☑ is transmitted herewith (required only if not transmitted by the International Bureau).
   - b. ☐ has been transmitted by the International Bureau
   - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2))
7. ☑ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   - a. ☑ are transmitted herewith (required only if not transmitted by the International Bureau).
   - b. ☐ have been transmitted by the International Bureau
   - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired
   - d. ☐ have not been made and will not be made
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3))
9. ☑ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4))
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 16 below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included
13. ☑ A FIRST preliminary amendment
    ☑ A SECOND or SUBSEQUENT preliminary amendment
14. ☐ A substitute specification
15. ☐ A change of power of attorney and/or address letter.
16. ☑ Other items or information: chèque .

U.S. APPLICATION NO (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
	PCT/GB96/01773	

17 ☑ The following fees are submitted	CALCULATIONS PTO USE ONLY
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):	
Search Report has been prepared by the EPO or JPO $910.00	
International preliminary examination fee paid to USPTO (37 CFR 1.482) $700.00	
No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) . . . $770.00	
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO $1040.00	
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) . . . $96.00	
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ ~~400~~ 920 ← new amounts?
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total claims	- 20 =		X $22.00	$
Independent claims	- 3 =		X $80.00	$
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ $260.00	$ 270
TOTAL OF ABOVE CALCULATIONS =				$ 1190
Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also by filed (Note 37 CFR 1.9, 1.27, 1.28).				$ - 595
SUBTOTAL =				$ 595
Processing fee of $130.00 for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)).			+	$ —
TOTAL NATIONAL FEE =				$ 595
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) $40.00 per property			+	$
TOTAL FEES ENCLOSED =				$ 595
			Amount to be: refunded	$
			charged	$

a. ☑ A check in the amount of $595 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No _____ in the amount of $_____ to cover the above fees
A duplicate copy of this sheet is enclosed

c. ☐ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No _____. A duplicate copy of this sheet is enclosed

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

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SIGNATURE

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European Patent Office
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Netherlands

January 5, 1998

Dear Sirs,

Re: PCT Application No. PCT/GB9601773

Thank you for your fax of 11th December and other information sent by post.

Enclosed, please find, in triplicate, copies of replacement pages 1, 8, 9 & 10 for old pages 1, 8, 9 & 10, and additional page 1a to be inserted between new page 1 and old page 2.

We would greatly appreciate acknowledgement of receipt of the enclosed.
Thank you for your kind attention.

Yours faithfully

J MARLOWE
Applicant

Enc. Replacement pages 1, 8, 9 & 10; new page 1a (3 copies of each page)

A MAGNETIC FILTER DEVICE

- Description -

The present invention relates to a magnetic filter device for filtering ferromagnetic material from a fluid in which said material is suspended.

Fluid such as engine oil which circulates in an engine and/or gearbox, and hydraulic fluid which circulates in hydraulic systems, tends to accumulate ferrous material from metallic surfaces which are lubricated by the fluid. Such particulate material in suspension is liable to accelerate wear of these surfaces and thereby generate even more ferrous matter.

Conventional filters fail to filter out a substantial amount of ferrous material from the fluid, which material, is liable to cause damage to an engine and/or gearbox or hydraulic system. In addition, as there is no indication of the quantity of ferrous material in the fluid, the fluid conventionally, is changed after the engine or hydraulic system has been run for a certain period of time, in order to limit possible damage.

Previous attempts at magnetic filtration include the device of US 2 149 764 (FREI). This device has a series of cylindrical magnets separated by a series of baffle plates, which are magnetised through contact with the magnets. A cylindrical mesh encloses this arrangement, and is in turn magnetised through contact with the baffle plates. The mesh increases the magnetised area and is constrained to be part of the flow path. However, fluid flow will be disadvantageously impeded by the eventual build up of metal particles on the mesh. This arrangement furthermore generates different magnetic flux fields to the device of the present invention.

Another device FR 114 135 (PHILIPS) uses non-corrosive plates disposed either side of a cylindrical magnet. The plates are of a thickness and overall design in order to maximise the magnetisable surface area, the gaps in the plates acting as passageways. Metal is said to collect radially between the fingers of the plates.

GB 684 052 (SPODIG) shows different arrangements of magnets and plates. One such arrangement is an intermediate plate sandwiched between like poles of two magnets, with further outer plates attached to the outer faces of the magnets. It is designed so that no lines of force originate from the outer surfaces of the plates, and also so that magnetic fields are focused around the intermediate plate. The orientation of plates and magnet in the device of the present invention, is described as having the drawback of stray fields, and a limited collection area which would bulge, the magnetic field only being effective at the outer edge of the magnetic system, with a detrimental stray effect of the air gap. For the purpose of collecting particles, the ideal way, according to SPODIG, is to sandwich as thin a plate as possible, and to increase the axial lengths of the magnets, so as to hold particles up against the curved peripheral surfaces of the magnets. It is designed so that lines of force are not generated from the outer plates, and it thereby operates on a different principle to that of the present invention.

A magnetic filter device for filtering ferromagnetic material from a fluid in which said material is suspended, has an inlet means and an outlet means which are isolated from each other within the device. A pair of annular plates are attached to either side of an annular magnet of smaller diameter, which sides are of opposing magnetic polarity to thus generate a magnetic field between the pair of plates. Each plate is recessed to form radially extending pole pieces. The plates are oriented with respect to each other so that the pole pieces and recesses are axially aligned. The magnetic flux distributions thus created, divert ferromagnetic material in the fluid towards the regions defined by opposite pairs of pole pieces.

In use, the magnetic filter device can be inserted between a containing means or engine, and a conventional filter or pump, so as to enhance the collection of ferromagnetic material from the circulating fluid.

- Claims -

1. A device for filtering ferromagnetic material from a fluid in which said material is suspended, comprises a magnet (2) and a pair of metal plates (5, 6), said magnet (2) having faces (3, 4) of opposite magnetic polarity, said plates (5, 6) being disposed in abutment with said faces (3, 4) respectively, each plate having a plurality of recesses (7, 8) about an outer perimeter (9, 10) of each plate (5, 6) to form radially extending magnetic pole pieces (11, 12), which extend beyond an outer perimeter of the magnet faces, said plates (5, 6) being oriented so that the recesses (7) and pole pieces (11) on one plate (5) are axially aligned with those recesses (8) and pole pieces (12) on the other plate (6), wherein axially opposite recesses (7, 8) define passage means for said fluid and also regions from which ferromagnetic material is repelled, and wherein said pole pieces (11, 12) define regions to which ferromagnetic material is attracted and retained, said device being further provided with a distribution plate (21) having a plurality of apertures (24) which are axially alignable with said recesses (7, 8), said apertures (24) being the only passage means of fluid to said metal plates (5, 6), characterised in that the distribution plate (21), the magnet (2) and said metal plates (5, 6) are each provided with an aperture which is adapted to receive a tube (20) through which fluid can pass, said tube providing means for isolating, within the device, fluid passage in the tube from fluid flow through the recesses (7, 8).

2. A device as in claim 1, characterised in that each recess (7, 8) and an outer edge of each pole piece (11, 12) is further provided with one or a plurality of slots (15).

3. A device as in claims 1 to 2, characterised in that the outer edges of axially facing pole pieces (11, 12) are curved towards one another.

4. A device as in claims 1 to 3, characterised in that means are provided for ensuring that said recesses (7, 8) and said apertures (24) are maintained in axial alignment.

5. A device as in claims 1 to 4 characterised in that the distribution plate (21) is made of a non-ferromagnetic material.

6. A device as in claims 1 to 5 characterised in that the magnet (2) is made of a material which will generate a magnetic field between the metal plates (5, 6) which is strong enough to attract ferromagnetic material from fluid passing therebetween.

7. A device as in claims 1 to 6 characterised in that the metal plate (5) which is impinged first by fluid flow through the device, is thicker than the other metal plate (6) through which fluid leaves the device.

8. A device as in claims 1 to 7 characterised in that an outer face of the tube (20) is provided with a recess (31) which can receive retaining means (32) which is able to keep the distribution plate (21) in abutment with the axially closer of said metal plates (5).

9. A device as in claims 1 to 8 characterised in that a housing is further provided, which is adapted at one end to be received by a containing means of said fluid, said containing means having an input means and an output means, the housing being adapted at the other end to receive a filter of known type, an output of which known filter is continuous with the tube (20) in the magnetic filter device and also the input means to the containing means, said output means from the containing means being continuous with the apertures (24) in the distribution plate (21) and the recesses (7, 8) in the metal plates (5, 6).

10. A device as in claim 1 characterised in that two distribution plates are disposed either side of each of the metal plates, each distribution plate having a plurality of apertures which are axially alignable with said recesses, said apertures being the only passage means of fluid to said metal plates, the apertures in both distribution plates providing inlet and outlet means for bi-directional axial flow of fluid.

11. A magnetic filter device for filtering ferromagnetic material from a fluid in which said material is suspended, comprises a known filter (35), a magnet (2) and a pair of metal plates (5, 6), said magnet (2) having faces (3, 4) of opposite magnetic polarity, said plates being disposed in abutment with said faces respectively, each plate (5, 6) having a plurality of recesses (7, 8) about an outer perimeter of each plate (5, 6) to form radially extending magnetic pole pieces (11, 12), which extend beyond an outer perimeter of the magnet faces, said plates (5, 6) being oriented so that the recesses (7) and pole pieces (11) on one plate (5) are axially aligned with those recesses (8) and pole pieces (12) on the other plate (6), wherein axially opposite recesses (7, 8) define passage means for said fluid and also regions from which ferromagnetic material is repelled, and wherein said pole pieces (11, 12) define regions to which ferromagnetic material is attracted and retained, said known filter having passage means for said fluid which is continuous with fluid passage through said recesses, said device being further provided with a distribution plate (21) having a plurality of apertures (24) which are axially alignable with said recesses (7, 8), said apertures (24) being the only passage means of fluid to said metal plates (5, 6), characterised in that the distribution plate (21), the magnet (2) and said metal plates (5, 6) are each provided with an aperture which is adapted to receive a tube (20) through which fluid can pass, said tube providing means for isolating, within the device, fluid passage in the tube from fluid flow through the recesses (7, 8).

To: FAX NO. 00 4989 2399-4465
No. of pages: 4
Entire document to follow by post

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Mr. Ch. Tompouloglou,
IPEA
European Patent Office,
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25th July, 1997

Dear Mr. Tompouloglou,

International Application No.	**PCT/GB 96/ 01773 - 2.1.13**
International filing date:	24.07.1996
Priority date:	26.07.1995

Further to official correspondence of 7.7.97, I enclose three copies of the revised claims.

Referring back to our telephone conversation of 19th June 1997, new claim 1 now encompasses features in original claims 1 to 3, in order to comply with the requirement of a distinguishing feature in claim 1. The other independent claim (new claim 11) has likewise been amended. The wording of the other claims has also been amended to clarify their respective characterising features.

Please do not hesitate to contact me on **0151 475 0047 (tel.), 0151 735 1447 (fax.)** if other changes are required.

We would like to thank the Examiner for the further opportunity given to revise the claims.

Yours faithfully,

ARLENE T. HALL

- Claims -

1. A device for filtering ferromagnetic material from a fluid in which said material is suspended, comprises a magnet and a pair of metal plates, said magnet having faces of opposite magnetic polarity, said plates being disposed in abutment with said faces respectively, each plate having a plurality of recesses about an outer perimeter of the plate to form radially extending magnetic pole pieces, which extend beyond an outer perimeter of the magnet faces, said plates being oriented so that the recesses and pole pieces on one plate are axially aligned with those recesses and pole pieces on the other plate, wherein axially opposite recesses define passage means for said fluid and also regions from which ferromagnetic material is repelled, and wherein said pole pieces define regions to which ferromagnetic material is attracted and retained, said device being further provided with a distribution plate having a plurality of apertures which are axially alignable with said recesses, said apertures being the only passage means of fluid to said metal plates, characterised in that the distribution plate, the magnet and said metal plates are each provided with an aperture which is adapted to receive a tube through which fluid can pass, said tube providing means for isolating, within the device, fluid passage in the tube from fluid flow through the recesses.

2. A device as in claim 1, characterised in that each recess and an outer edge of each pole piece is further provided with one or a plurality of slots.

3. A device as in claims 1 to 2, characterised in that the outer edges of axially facing pole pieces are curved towards one another.

4. A device as in claims 1 to 3, characterised in that means are provided for ensuring that said recesses and said apertures are maintained in axial alignment.

5. A device as in claims 1 to 4, characterised in that the distribution plate is made of a non-ferromagnetic material.

6. A device as in claims 1 to 5, characterised in that the magnet is made of a material which will generate a magnetic field between the metal plates which is strong enough to attract ferromagnetic material from fluid passing therebetween.

7. A device as in claims 1 to 6, characterised in that the metal plate which is impinged first by fluid flow through the device, is thicker than the other metal plate through which fluid leaves the device.

8. A device as in claims 3 to 9, characterised in that an outer face of the tube is provided with a recess which can receive retaining means which is able to keep the distribution plate in abutment with the axially closer of said metal plates.

9. A device as in claims 1 to 8, characterised in that a housing is further provided, which is adapted at one end to be received by a containing means of said fluid, said containing means having an input means and an output means, the housing being adapted at the other end to receive a filter of known type, an output of which known filter is continuous with the tube in the magnetic filter device and also the input means to the containing means, said output means from the containing means being continuous with the apertures in the distribution plate and the recesses in the metal plates.

10. A device as in claim 1, characterised in that two distribution plates are disposed either side of each of the metal plates, each distribution plate having a plurality of apertures which are axially alignable with said recesses, said apertures being the only passage means of fluid to said metal plates, the apertures in both distribution plates providing inlet and outlet means for bi-directional axial flow of fluid.

11. A magnetic filter device for filtering ferromagnetic material from a fluid in which said material is suspended, comprises a known filter, a magnet and a pair of metal plates, said magnet having faces of opposite magnetic polarity, said plates being disposed in abutment with said faces respectively, each plate having a plurality of recesses about an outer perimeter of the plate to form radially extending magnetic pole pieces, which extend beyond an outer perimeter of the magnet faces, said plates being oriented so that the recesses and pole pieces on one plate are axially aligned with those recesses and pole pieces on the other plate, wherein axially opposite recesses define passage means for said fluid and also regions from which ferromagnetic material is repelled, and wherein said pole pieces define regions to which ferromagnetic material is attracted and retained, said known filter having passage means for said fluid which is continuous with fluid passage through said recesses, said device being further provided with a distribution plate having a plurality of apertures which are axially alignable with said recesses, said apertures being the only passage means of fluid to said metal plates, characterised in that the distribution plate, the magnet and said metal plates are each provided with an aperture which is adapted to receive a tube through which fluid can pass, said tube providing means for isolating, within the device, fluid passage in the tube from fluid flow through the recesses.

PTO/SB/09 (10-96)
Approved for use through 10/31/99 OMB 0651-0031
Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

VERIFIED STATEMENT CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) & 1.27(b))—INDEPENDENT INVENTOR	Docket Number (Optional)

Applicant or Patentee: HALL, Harold

Application or Patent No.: PCT/GB96/01773

Filed or Issued: JULY 24 1996 (International Filing Date)

Title: A MAGNETIC FILTER DEVICE

As a below named inventor, I hereby declare that I qualify as an independent inventor as defined in 37 CFR 1.9(c) for purposes of paying reduced fees to the Patent and Trademark Office described in

- ☐ the specification filed herewith with title as listed above
- ☑ the application identified above.
- ☐ the patent identified above.

I have not assigned, granted, conveyed, or licensed, and am under no obligation under contract or law to assign, grant, convey, or license, any rights in the invention to any person who would not qualify as an independent inventor under 37 CFR 1.9(c) if that person had made the invention, or to any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e).

Each person, concern, or organization to which I have assigned, granted, conveyed, or licensed or am under an obligation under contract or law to assign, grant, convey, or license any rights in the invention is listed below:

- ☐ No such person, concern, or organization exists.
- ☑ Each such person, concern, or organization is listed below

MARLOWE, John

Separate verified statements are required from each named person, concern, or organization having rights to the invention averring to their status as small entities. (37 CFR 1.27)

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

Harold HALL		
NAME OF INVENTOR	NAME OF INVENTOR	NAME OF INVENTOR
H Hall		
Signature of inventor	Signature of inventor	Signature of inventor
Date January 13, 1998	Date	Date

PTO/SB/10 (10-96)
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Patent and Trademark Office, U S DEPARTMENT OF COMMERCE

VERIFIED STATEMENT CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) & 1.27(c))-(INDIVIDUAL SMALL BUSINESS) CONCERN)	Docket Number (Optional)

Applicant or Patentee: HALL, Harold
Application or Patent No.: PCT/GB96/01773
Filed or Issued: July 24 1996 (International Filing Date)
Title: A MAGNETIC FILTER DEVICE

I hereby declare that I am INDIVIDUAL
☑ the owner of the small business concern identified below:
☐ an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF (SMALL BUSINESS CONCERN) INDIVIDUAL MARLOWE, John

ADDRESS OF SMALL BUSINESS CONCERN 3 DOMINIC ROAD, CHILDWALL, LIVERPOOL ENGLAND UK. L16 1JY

I hereby declare that the above identified small business concern qualifies as a small business concern as defined in 13 CFR 121.12, and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees to the United States Patent and Trademark Office, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time, or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention described in:

☐ the specification filed herewith with title as listed above.
☑ the application identified above.
☐ the patent identified above.

If the rights held by the above identified small business concern are not exclusive, each individual, concern, or organization having rights in the invention must file separate verified statements averring to their status as small entities, and no rights to the invention are held by any person, other than the inventor, who would not qualify as an independent inventor under 37 CFR 1.9(c) if that person made the invention, or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d), or a nonprofit organization under 37 CFR 1.9(e).

Each person, concern, or organization having any rights in the invention is listed below:
☒ no such person, concern, or organization exists.
☐ each such person, concern, or organization is listed below.

Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 CFR 1.27)

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME OF PERSON SIGNING MARLOWE, John

TITLE OF PERSON IF OTHER THAN OWNER

ADDRESS OF PERSON SIGNING 3 DOMINIC RD, CHILDWALL LIVERPOOL, ENGLAND UK. L16 1JY

SIGNATURE [signature] DATE Jan 13, 1998

A MAGNETIC FILTER DEVICE

- Description -

The present invention relates to a magnetic filter device for filtering ferromagnetic material from a fluid in which said material is suspended.

Fluid such as engine oil which circulates in an engine and/or gearbox, and hydraulic fluid which circulates in hydraulic systems, tends to accumulate ferrous material from metallic surfaces which are lubricated by the fluid. Such particulate material in suspension is liable to accelerate wear of these surfaces and thereby generate even more ferrous matter.

Conventional filters fail to filter out a substantial amount of ferrous material from the fluid, which material, is liable to cause damage to an engine and/or gearbox or hydraulic system. In addition, as there is no indication of the quantity of ferrous material in the fluid, the fluid conventionally, is changed after the engine or hydraulic system has been run for a certain period of time, in order to limit possible damage.

A magnetic filter device for filtering ferromagnetic material from a fluid in which said material is suspended, has an inlet means and an outlet means which are isolated from each other within the device. A pair of annular plates are attached to either side of an annular magnet of smaller diameter, which sides are of opposing magnetic polarity to thus generate a magnetic field between the pair of plates. Each plate is recessed to form radially extending pole pieces. The plates are oriented with respect to each other so that the pole pieces and recesses are axially aligned. The magnetic flux distributions thus created, divert ferromagnetic material in the fluid towards the regions defined by opposite pairs of pole pieces.

In use, the magnetic filter device can be inserted between a containing means or engine, and a conventional filter or pump, so as to enhance the collection of ferromagnetic material from the circulating fluid.

In accordance with one aspect of the present invention, a magnetic filter device for filtering ferromagnetic material from a fluid in which said material is suspended, comprises a magnet and a pair of metal plates, said magnet having faces of opposite magnetic polarity, said plates being disposed in abutment with said faces respectively, each plate having a plurality of recesses about an outer perimeter of the plate to form radially extending magnetic pole pieces, which extend beyond an outer perimeter of the magnet faces, said plates being oriented so that the recesses and pole pieces on one plate are axially aligned with those recesses and pole pieces on the other plate, wherein axially opposite recesses define passage means for said fluid and also regions from which ferromagnetic material is repelled, and wherein said pole pieces define regions to which ferromagnetic material is attracted and retained.

Preferably, the magnetic filter device is further provided with a distribution plate having a plurality of apertures which are axially alignable with said recesses, said apertures being the only passage means of fluid to said metal plates.

It is further preferred that the distribution plate, the magnet and said metal plates are each provided with a central hole which is adapted to receive a tube through which fluid can pass, said tube providing means for isolating, within the device, fluid passage in the tube from fluid flow through the recesses.

Advantageously, each recess and an outer edge of each pole piece is further provided with one or a plurality of slots.

Preferably, the outer edges of axially facing pole pieces are curved towards one another.

It is preferred that means are provided for ensuring that said recesses and said apertures are maintained in axial alignment.

The distribution plate is advantageously made of a non-ferromagnetic material. This would discourage any collection of ferromagnetic material thereon.

The magnet is advantageously made of a material which will generate a magnetic field between the metal plates which is strong enough to attract ferromagnetic material from fluid passing therebetween.

The metal plate which is impinged first by fluid flow through the device, is advantageously thicker than the other metal plate through which fluid leaves the device.

Preferably, an outer face of the tube is provided with a recess which can receive retaining means which is able to keep the distribution plate in abutment with the axially closer of said metal plates.

Advantageously, a housing is further provided, which is adapted at one end to be received by a containing means of said fluid, said containing means having an input means and an output means, the housing being adapted at the other end to receive a filter of known type, an output of which known filter is continuous with the tube in the magnetic filter device and also the input means to the containing means, said output means from the containing means being continuous with the apertures in the distribution plate and the recesses in the metal plates.

In a further embodiment, the magnetic filter device is provided with two distribution plates disposed either side of each of the metal plates, each distribution plate having a plurality of apertures which are axially alignable with said recesses, said apertures being the only passage means of fluid to said metal plates, the apertures in both distribution plates providing inlet and outlet means for bi-directional axial flow of fluid.

In accordance with a further aspect of the present invention, there is provided a magnetic filter device for filtering ferromagnetic material from a fluid in which said material is suspended, which comprises a known filter, a magnet and a pair of metal plates, said magnet having faces of opposite magnetic polarity, said plates being disposed in abutment with said faces respectively, each plate having a plurality of recesses about an outer perimeter of the plate to form radially extending magnetic pole pieces, which extend beyond an outer perimeter of the magnet faces, said plates being oriented so that the recesses and pole pieces on one plate are axially aligned with those recesses and pole pieces on the other plate, wherein axially opposite recesses define passage means for said fluid and also regions from which ferromagnetic material is

repelled, and wherein said pole pieces define regions to which ferromagnetic material is attracted and retained, said known filter having passage means for said fluid which is continuous with fluid passage through said recesses.

A specific embodiment of the present invention will now be described with reference to the accompanying drawings, in which:

Fig. 1 is a cross-section through a magnetic filter device in accordance with one aspect of the present invention;

Fig. 2 is an exploded perspective view of the device in fig.1;

Fig. 3 is a top view of the distribution plate in figs. 1 & 2,

Fig. 4 is a top view of one of the metal plates in the device, and

Fig. 5 is a schematic diagram illustrating one application of the device in figs. 1 to 4.

A magnetic filter device 1, as shown in figs.1 & 2, for filtering ferromagnetic material (not shown) from a fluid (not shown) in which said material is suspended, comprises a magnet 2 having two faces 3, 4 of opposite magnetic polarity, against which faces 3, 4, abut metal plates 5, 6, respectively. The plates 5, 6 are provided with a plurality of recesses 7, 8 respectively, in outer circumferential edges 9, 10 of said plates 5, 6 so as to form pole pieces 11, 12 as shown in figs. 2 and 4. Equal numbers of such pole pieces, 11, 12 are formed in each plate 5, 6, and the latter oriented so that the pole pieces 11 and recesses 7 of the plate 5, are axially aligned with the respective pole pieces 12 and recesses 8 of the plate 6. Axially displaced pairs of pole pieces 11, 12 have opposite magnetic polarity by virtue of their respective locations on the faces 3, 4 of the magnet 2. They overlap an outer edge 13 of the magnet 2 to define radially extending collecting regions 14 in which ferromagnetic particles subject to the magnetic fields generated therein, can be retained. The ends of each pair of pole pieces 11, 12 are curved towards each other to further enhance the strength and distribution of the magnetic fields. Furthermore, because each recess 7, 8 is flanked radially by

portions of metal of like polarity, ferromagnetic material is repelled towards the collecting regions 14 and also away from the path of fluid flow.

Each pole piece 11, 12 and each recess 7, 8 is further provided with a slot 15. Each slot 15 defines adjacent regions of like polarity in which a strongly repelling magnetic field is thus generated. Such fields further promote the retention of ferromagnetic material to the regions 14 between facing pole pieces.

Apertures 16, 17 centrally disposed in plates 5, 6 axially align with a central aperture 18 in the magnet 2 to form a channel 19 in the device 1, in which a central tube 20 is disposed. The tube 20 extends beyond the collective thicknesses of the plates 5, 6 and the magnet 2.

A distribution plate 21, as shown in fig. 3, has a central aperture 22 which enables the distribution plate 21 to be threaded over an end 23 of the central tube 20, so as to be disposed adjacent to the metal plate 5. The plate 21 is further provided with apertures 24 equal in number to the recesses 7, 8 in each of the plates 5, 6. The distribution plate 21 is disposed about the tube 20 so that the apertures 24 are axially aligned with the recesses 7, 8 in the metal plates 5, 6. The plates 5, 6 are each provided with flats 25, 26 in the apertures 16, 17 respectively, and the aperture 22 of the distribution plate 21 is also provided with a flat 27 of similar size. In the orientation described above where the apertures 24 and the recesses 7, 8 are in axial alignment, the flats 25, 26 and 27 are also axially aligned. The tube 20 is provided with a flattened region 28 on an outer face 30 against which the flats 25, 26 and 27 of the plates 5, 6 and 21 are disposed in order to maintain the above-mentioned orientation when the magnetic filter device 1 is assembled.

The distribution plate 21 has a flange portion 29 about the central aperture 22. The outer face 30 of the central tube 20 is further provided with an annular recess 31 which is adapted to receive a circlip 32 which abuts the flange portion 29 when the distribution plate 21 is in abutment with the metal plate 5.

The distribution plate 21 may be circumferentially sealed against a housing (not shown) to ensure that only fluid which flows through apertures 24 in the distribution plate 21 passes through to the recesses 7, 8.

In one example of an application of the magnetic filter device 1, the latter is removeably disposed between a known containing means 33 for fluid 34 to be filtered in a system in use (not shown), and a known filter unit 35, as shown in fig. 5.

The known filter unit 35 is attachable to the containing means 33 by means of a bolt 36 which enters a lower face of the filter unit 35, passes through its centre, continues out through an upper portion of the unit 35 and screws into a part of the containing means 33. A spring 37 provided between a block of filter material 38 and a base of the filter unit 35 is further compressed to accommodate the insertion of the magnetic filter device 1 between the containing means 33 and the filter unit 35.

The distribution plate 21 is sealed against the filter unit 35 by annular sealing means 39. The central tube 20 is sealed against the containing means 33 and a surface 40 of the known filter unit 35 by sealing means 41 and 42 respectively.

Fluid 34 exits the containing means 33 through an outlet port 43. It flows towards the distribution plate 21 and thus through axially coincident apertures 24 and recesses 7, 8 in the distribution plate 21 and the plates 5, 6 respectively. From the magnetic filter device 1, fluid enters the known filter unit 35 and flows to the filter material 38, in which other particles in suspension can be retained. Fluid exits the filter material 38 and flows through a central passage 44 which is continuous with the central tube 20 of the magnetic filter device 1. From the central tube 20 of the device 1, fluid re-enters the containing means 33 through an input port 45. It is then recirculated around the system in use before its return to the outlet port 43. More ferromagnetic material is retained with the increased frequency of circulation of fluid through the magnetic filter device 1.

In the event of blockage of the filter material 38, a pressure relief valve 46 allows fluid to bypass the filter material 38 and proceed through to the central passage 44. Material retained in the filter material 38 up to this point may then be

disadvantageously washed back into the circulation. However, since fluid input into the magnetic filter device 1 is isolated from fluid output, any particles collected in the magnetic filter device 1 will be retained in such an event.

In such an arrangement, the magnetic filter device 1, can act as a convenient check point for the amount of wear on engine and/or gearbox components or hydraulic system, and therefore enhance their safety and efficiency.

In a further embodiment, the magnetic filter device can be oriented with respect to a known filter unit so as to have the distribution plate 21 facing the direction of fluid flow.

In a further embodiment, the filter device can be an integral member of a known filter unit.

- Claims -

1. A device for filtering ferromagnetic material from a fluid in which said material is suspended, comprises a magnet and a pair of metal plates, said magnet having faces of opposite magnetic polarity, said plates being disposed in abutment with said faces respectively each plate having a plurality of recesses about an outer perimeter of the plate to form radially extending magnetic pole pieces, which extend beyond an outer perimeter of the magnet faces, said plates being oriented so that the recesses and pole pieces on one plate are axially aligned with those recesses and pole pieces on the other plate, wherein by opposite recesses define passage means for said fluid and also regions from which omagnetic material is repelled, and wherein said pole pieces define regions to which ferromagnetic material is attracted and retained, said device being further provided with a distribution plate having a plurality of apertures which are axially alignable with said recesses, said apertures being the only passage means of fluid to said metal plates, characterised in that the distribution plate, the magnet and said metal plates are each provided with an aperture which is adapted to receive a tube through which fluid can pass, said tube providing means for isolating, within the device, fluid passage in the tube from fluid flow through the recesses.

2. A device as in claim 1, characterised in that each recess and an outer edge of each p piece is further provided with one or a plurality of slots.

3. A device as in claims 1 to 2, characterised in that the outer edges of axially facin pieces are curved towards one another.

4. A device as in claims 1 to 3, characterised in that means are provided for ens said recesses and said apertures are maintained in axial alignment.

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11. A magnetic filter device for filtering ferromagnetic material from a fluid in which said material is suspended, comprises a known filter, a magnet and a pair of metal plates, said magnet having faces of opposite magnetic polarity, said plates being disposed in abutment with said faces respectively, each plate having a plurality of recesses about an outer perimeter of the plate to form radially extending magnetic pole pieces, which extend beyond an outer perimeter of the magnet faces, said plates being oriented so that the recesses and pole pieces on one plate are axially aligned with those recesses and pole pieces on the other plate, wherein axially opposite recesses define passage means for said fluid and also regions from which ferromagnetic material is repelled, and wherein said pole pieces define regions to which ferromagnetic material is attracted and retained, said known filter having passage means for said fluid which is continuous with fluid passage through said recesses, said device being further provided with a distribution plate having a plurality of apertures which are axially alignable with said recesses, said apertures being the only passage means of fluid to said metal plates, characterised in that the distribution plate, the magnet and said metal plates are each provided with an aperture which is adapted to receive a tube through which fluid can pass, said tube providing means for isolating, within the device, fluid passage in the tube from fluid flow through the recesses.

- Claims -

1. A device for filtering ferromagnetic material from a fluid in which said material is suspended, comprises a magnet and a pair of metal plates, said magnet having faces of opposite magnetic polarity, said plates being disposed in abutment with said faces respectively, each plate having a plurality of recesses about an outer perimeter of the plate to form radially extending magnetic pole pieces, which extend beyond an outer perimeter of the magnet faces, said plates being oriented so that the recesses and pole pieces on one plate are axially aligned with those recesses and pole pieces on the other plate, wherein axially opposite recesses define passage means for said fluid and also regions from which ferromagnetic material is repelled, and wherein said pole pieces define regions to which ferromagnetic material is attracted and retained, said device being further provided with a distribution plate having a plurality of apertures which are axially alignable with said recesses, said apertures being the only passage means of fluid to said metal plates, characterised in that the distribution plate, the magnet and said metal plates are each provided with an aperture which is adapted to receive a tube through which fluid can pass, said tube providing means for isolating, within the device, fluid passage in the tube from fluid flow through the recesses.

2. A device as in claim 1, characterised in that each recess and an outer edge of each pole piece is further provided with one or a plurality of slots.

3. A device as in claims 1 to 2, characterised in that the outer edges of axially facing pole pieces are curved towards one another.

4. A device as in claims 1 to 3, characterised in that means are provided for ensuring that said recesses and said apertures are maintained in axial alignment.

5. A device as in claims 1 to 4, characterised in that the distribution plate is made of a non-ferromagnetic material.

6. A device as in claims 1 to 5, characterised in that the magnet is made of a material which will generate a magnetic field between the metal plates which is strong enough to attract ferromagnetic material from fluid passing therebetween.

7. A device as in claims 1 to 6, characterised in that the metal plate which is impinged first by fluid flow through the device, is thicker than the other metal plate through which fluid leaves the device.

8. A device as in claims 3 to 9, characterised in that an outer face of the tube is provided with a recess which can receive retaining means which is able to keep the distribution plate in abutment with the axially closer of said metal plates.

9. A device as in claims 1 to 8, characterised in that a housing is further provided, which is adapted at one end to be received by a containing means of said fluid, said containing means having an input means and an output means, the housing being adapted at the other end to receive a filter of known type, an output of which known filter is continuous with the tube in the magnetic filter device and also the input means to the containing means, said output means from the containing means being continuous with the apertures in the distribution plate and the recesses in the metal plates.

10. A device as in claim 1, characterised in that two distribution plates are disposed either side of each of the metal plates, each distribution plate having a plurality of apertures which are axially alignable with said recesses, said apertures being the only passage means of fluid to said metal plates, the apertures in both distribution plates providing inlet and outlet means for bi-directional axial flow of fluid.

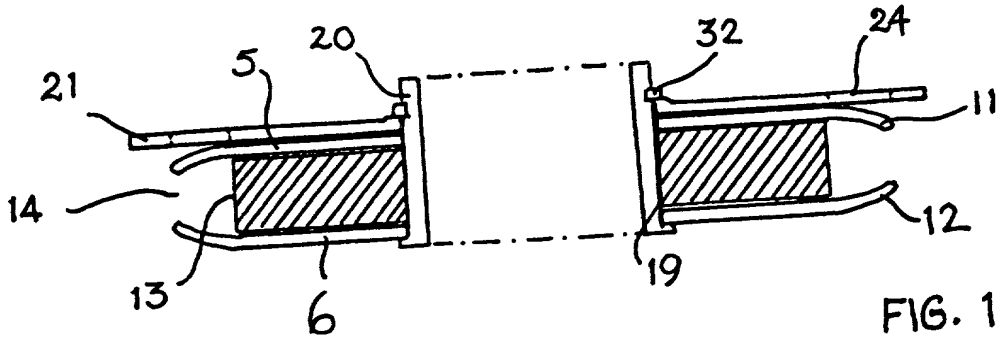

FIG. 1

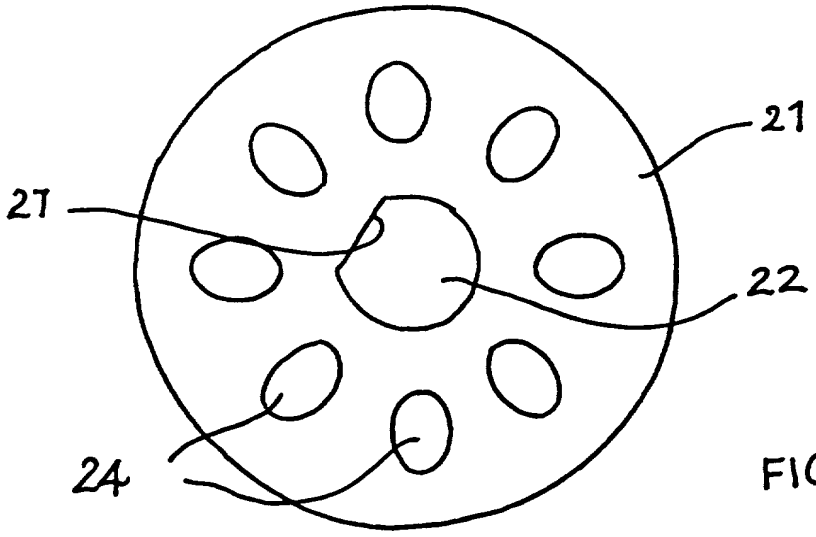

FIG. 3

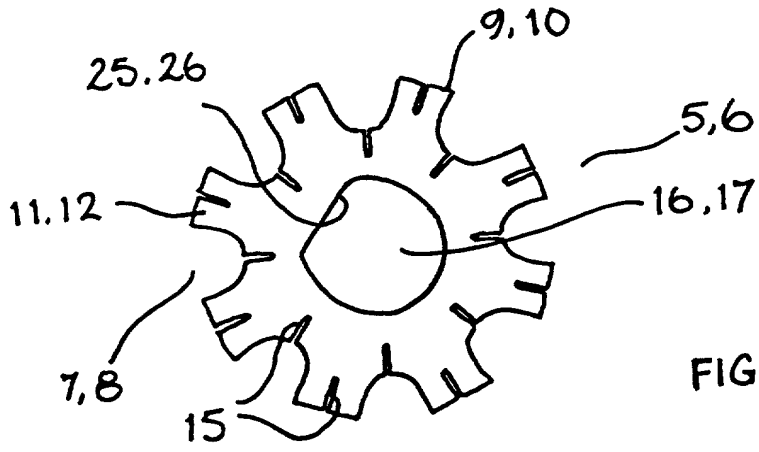

FIG. 4

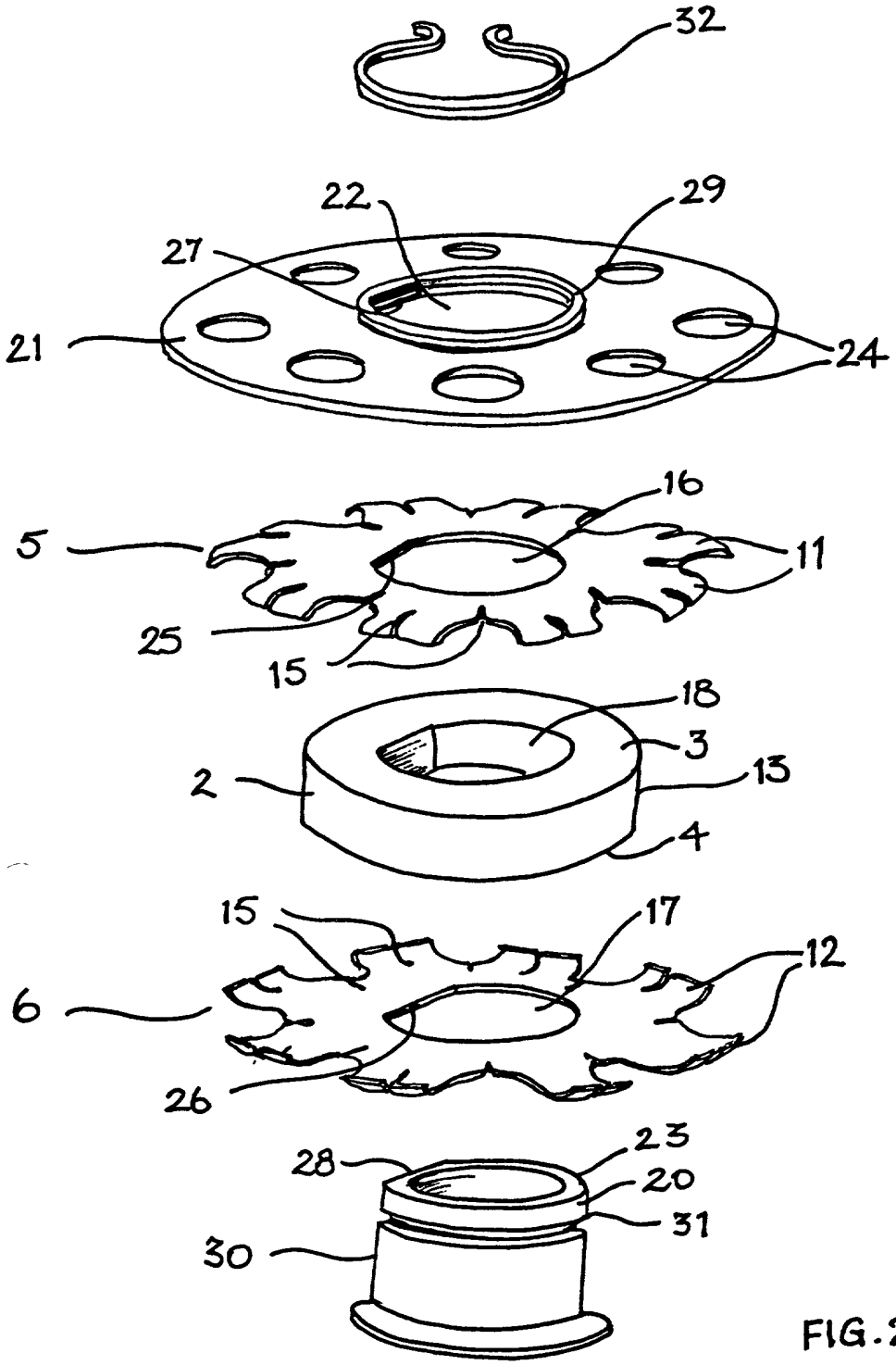

FIG.2

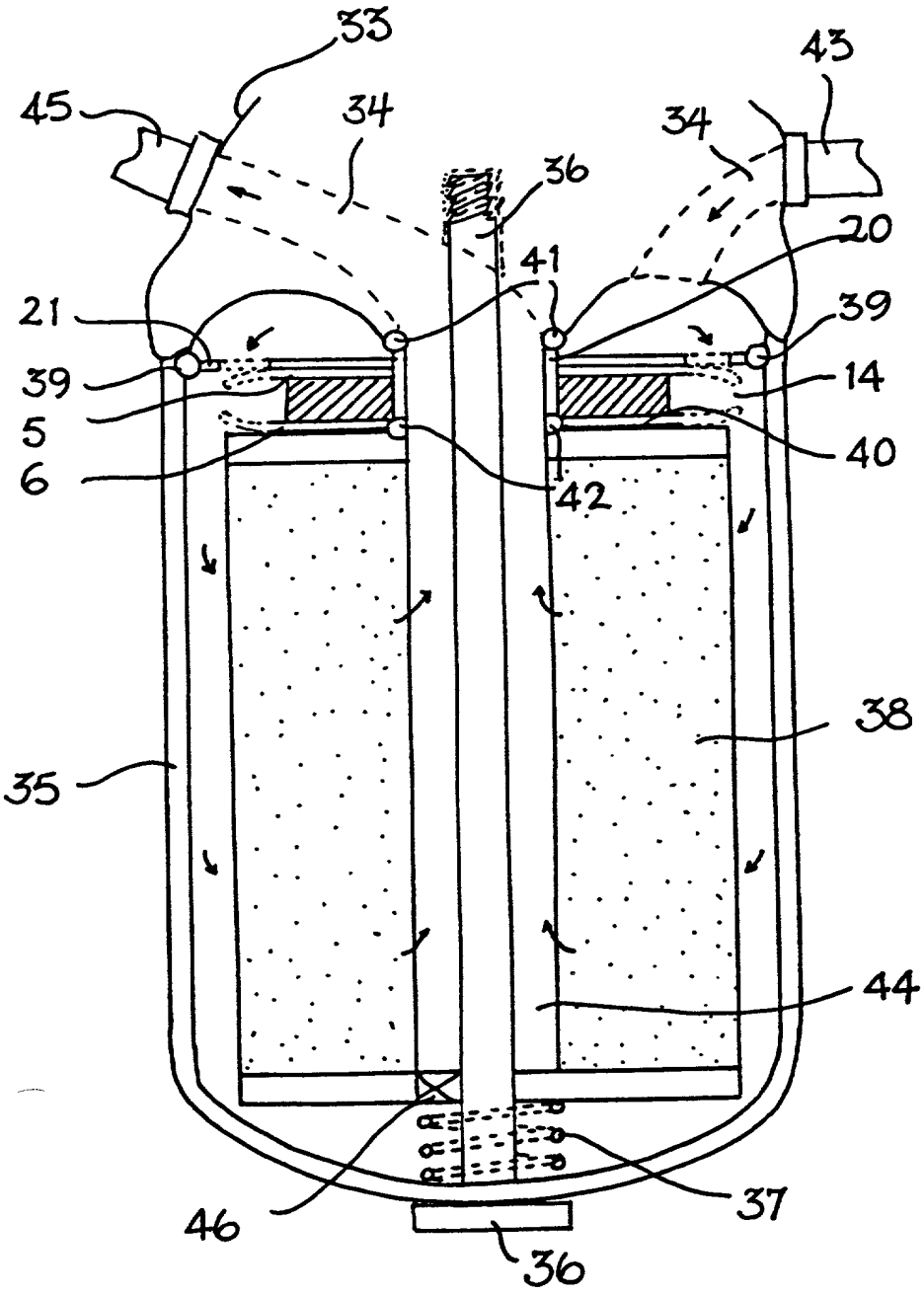

FIG. 5

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DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION

☐ Declaration Submitted with Initial Filing OR ☐ Declaration Submitted after Initial Filing

Attorney Docket Number	
First Named Inventor	HALL, Harold
COMPLETE IF KNOWN	
Application Number	
Filing Date	
Group Art Unit	
Examiner Name	

As a below named inventor, I hereby declare that.

My residence, post office address, and citizenship are as stated below next to my name

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

A MAGNETIC FILTER DEVICE

(Title of the invention)

the specification of which

☐ is attached hereto

OR

☑ was filed on (MM/DD/YYYY) JULY 24 1996 as United States Application Number or PCT International

Application Number PCT/GB96/01773 and was amended on (MM/DD/YYYY) JULY 25 1997 JAN 5 1998 (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37 Code of Federal Regulations, §1.56

I hereby claim foreign priority benefits under Title 35 United States Code §119 (a)-(d) or §365(b) of any foreign application(s) for patent or inventor's certificate, or §365 (a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached? YES	NO
9515352.4	GB	JULY 26 1995	☐	copy only ☑	☐
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐

☐ Additional foreign application numbers are listed on a supplemental priority sheet attached hereto

I hereby claim the benefit under Title 35 United States Code § 119(e) of any United States provisional application(s) listed below

Application Number(s)	Filing Date (MM/DD/YYYY)

☐ Additional provisional application numbers are listed on a supplemental priority sheet attached hereto.

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DECLARATION

I hereby claim the benefit under Title 35, United States Code §120 of any United States application(s), or §365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. Parent Application Number	PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (if applicable)
—	PCT/GB96/01773	JULY/24/1996	

☐ Additional U S or PCT international application numbers are listed on a supplemental priority sheet attached hereto.

As a named inventor I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

Name	Registration Number	Name	Registration Number

☐ Additional registered practitioner(s) named on a supplemental sheet attached hereto.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon

Name of Sole or First Inventor: ☐ A petition has been filed for this unsigned inventor

Given Name	HAROLD	Middle Initial		Family Name	HALL	Suffix e g Jr.	
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Post Office Address							
City	LIVERPOOL	State		ZIP	L15 8JJ	Country	ENGLAND, U.K.

☐ Additional inventors are being named on supplemental sheet(s) attached hereto